Trajectory Propagation Models and Operational Software Comparison between JPL and GSFC/FDF for TOPEX/POSEIDON

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TOPEX/POSEIDON was launched on Aug 10, 1992 to study ocean circulation and its interaction with the atmosphere, to improve our knowledge of climate change and heat transport in the ocean, and to study the marine gravity field. These objectives are accomplished by accurately mapping the ocean surface with a precision on-board altimeter. Two independent Orbit Determination (OD) processes arc associated with the mission, A Precision Orbit Determination (POD) process which is used to support analysis of the altimeter data, and an Operational Orbit Determination (OOD) process which is used to support the daily satellite operations. The 00D is the responsibility of the GSFC Flight Dynamics Division (FDD). It utilizes TDRSS tracking data and produces, among other things, the satellite and TDRSS state vectors in the Extended Precision Vector (EPV) format. This EPV solution set is transferee to JPL via NASCOM to be used by the Navigation Team (NAVT) as initial conditions for propagating the Operational Orbit Ephemeris (OOE).

The TOPEX/POSEIDON project imposed several accuracy requirements on the 00E arising from a variety of error sources (Ref 1.). The driving requirement is associated with implementation of Orbit Maintenance Maneuvers (OMM) in such to maintain equator crossings of the satellite ground track within a 2 KM control band, To meet this control requirement, the 00E must have a maximum total 3 sigma error in equator crossing location of less than 750 meters in 30 days, The project further defines the JPL-GSFC interface by allocating all of the definitive OD error component to the FDF and the NAVT must then meet the overall requirements given the allocated FDF error contribution. The paper first addresses the requirements on the OOE with some emphasis on the prediction trajectory software modeling errors component (40 meters) in equator crossing error.

For the described interface to be effective it is essential that JPL and GSFC trajectory software system be equivalent (i.e. equivalence between JPL DPTRAJ and GSFC GTDS for TOPEX/POSEIDON specific models). Each system must model selected perturbation forces and the varying drag and solar radiation pressure mean areas equivalently. However the two systems usc different integration techniques and some modeling differences exist such as solar radiation pressure. Extensive effort was made during the development phase to ensure the compatibility of DPTRAJ and GTDS. This task started in 1987 by

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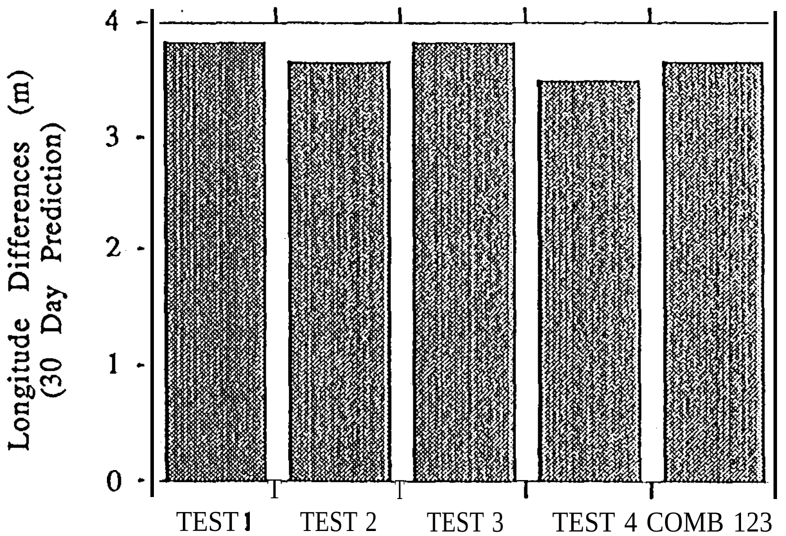
identifying the force models to be used in the two organizations, over the years many cases have been established to allow for a model-by-model comparison between DPTRAJ and GTDS. A 5-meter (out of the 40 meters prediction trajectory software modeling errors) longitude difference at equator crossing after 30 days was allocated as a derived requirement for JPL-FDF trajectory comparison tests. The figure shows the result of onc of these tests. The paper will summarize the results of all test cases conducted during the development phase. In all these cases the requirements were met.

During routine operations the FDF sends an EPV representation of an orbit solution to JPL from which the NAVT generates the OOE. Before utilizing the 00E to generate trajectory products, the NAVT assures the compatibility of the 00E with the EPV solution set by comparing the radial, cross-track and along-track components of the inertial orbit position as well as the difference in Earth-fixed longitude at ascending equator crossings. The paper will describe this routine activity.

Shortly after launch, OD indicated orbital decay levels about 60 times larger than could be explained by atmospheric drag. Later, orbit trend analysis indicated a presence of body-fixed residual along-track forces comparable to drag which cause either orbital decay or boost depending on the satellite attitude and solar array articulation mode. Consequently, plans with the FDF were made to estimate an along-track thrust multiplier $(1 + \tau)$ instead of the drag multiplier (τ = O indicates nominal thrust). To ensure the compatibility of thrust modeling between DPTRAJ and GTDS, the NAVT added to the DPTRAJ force model a continous finite burn with duration equal to the length of the OD arc and force equal to $(1 + \tau)$ micro Newton. The paper will also present the results of these compatibility tests. .

Reference:

1. TOPEX/POSEIDON Mission and Systems Requirements, 633-103, April 1989, JPL, Caltech.



JPL-FDF Trajectory Comparison Tests

Test 1: Two body only..
Test 2: Test 1 + 14x14 field and luni-solar gravity.
Tcst 3: Test 1 + luni-solar gravity and solid Earth tides,
Test 4: Test 1 + solar radiation pressure.